Pilot Testing of Mercury Oxidation Catalysts for Upstream of Wet FGD Systems

Quarterly Technical Progress Report

April 1, 2004 – June 30, 2004

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ABSTRACT

This document summarizes progress on Cooperative Agreement DE-FC26-01NT41185, "Pilot Testing of Mercury Oxidation Catalysts for Upstream of Wet FGD Systems," during the time-period April 1, 2004 through June 30, 2004. The objective of this project is to demonstrate at pilot scale the use of solid honeycomb catalysts to promote the oxidation of elemental mercury in the flue gas from coal combustion. The project is being funded by the U.S. DOE National Energy Technology Laboratory under Cooperative Agreement DE-FC26-01NT41185. EPRI, Great River Energy (GRE), and City Public Service (CPS) of San Antonio are project co-funders. URS Group is the prime contractor.

The mercury control process under development uses catalyst materials applied to honeycomb substrates to promote the oxidation of elemental mercury in the flue gas from coal-fired power plants that have wet lime or limestone flue gas desulfurization (FGD) systems. Oxidized mercury is removed in the wet FGD absorbers and co-precipitates with the byproducts from the FGD system. The current project is testing previously identified catalyst materials at a larger, pilot scale and in a commercial form, to provide engineering data for future full-scale designs. The pilot-scale tests will continue for approximately 14 months or longer at each of two sites to provide longer-term catalyst life data.

This is the eleventh full reporting period for the subject Cooperative Agreement. During this period, project efforts included continued operation of the first pilot unit at the GRE Coal Creek site with all four catalysts in service and sonic horns installed for on-line catalyst cleaning. During the quarter, one catalyst activity measurement trip was completed in June, including Ontario Hydro relative accuracy tests, and catalyst pressure drop was monitored while the sonic horns continued in operation. For the second pilot unit at CPS' Spruce Plant, the catalyst pilot unit continued in operation throughout the quarter. One catalyst activity measurement trip was conducted, in May.

This technical progress report details available results from these efforts at both sites.

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INTRODUCTION

This document is the quarterly Technical Progress Report for the project "Pilot Testing of Mercury Oxidation Catalysts for Upstream of Wet FGD Systems," for the time-period April 1, 2004 through June 30, 2004. The objective of this project is to demonstrate at pilot scale the use of solid honeycomb catalysts to promote the oxidation of elemental mercury in the flue gas from coal combustion. The project is being funded by the U.S. DOE National Energy Technology Laboratory under Cooperative Agreement DE-FC26-01NT41185. EPRI, Great River Energy (GRE) and City Public Service (CPS) of San Antonio are project co-funders. URS Group is the prime contractor.

The mercury control process under development uses catalyst materials applied to honeycomb substrates to promote the oxidation of elemental mercury in the flue gas from coal-fired power plants that have wet lime or limestone flue gas desulfurization (FGD) systems. The oxidizing species are already present in the flue gas, and may include chlorine, hydrochloric acid (HCl) and/or other species. Oxidized mercury is removed in the wet FGD absorbers and co-precipitates with the byproducts from the FGD system. The objective of this project is to test previously identified effective catalyst materials at a larger scale and in a commercial form to provide engineering data for future full-scale designs. The pilot-scale tests will continue for 14 months or longer at each of two sites to provide longer-term catalyst life data. After successful completion of the project, it is expected that sufficient full-scale test data will be available to design and implement demonstration-scale installations of the catalytic mercury oxidation technology.

The two utility team members are providing co-funding, technical input, and host sites for testing. GRE is providing the first test site at their Coal Creek Station (CCS), which fires a North Dakota lignite, and CPS is providing the second site at their J.K. Spruce Plant, which fires a Powder River Basin (PRB) subbituminous coal. These two host sites each have existing wet FGD systems downstream of high-efficiency particulate control devices, an ESP at CCS and a reverse-gas fabric filter (baghouse) at Spruce**.**

The remainder of this report is divided into five sections: an Executive Summary followed by a section that describes Experimental procedures, then sections for Results and Discussion, Conclusions, and References.

EXECUTIVE SUMMARY

Summary of Progress

The current reporting period, April 1, 2004 through June 30, 2004, is the eleventh full technical progress reporting period for the project. Efforts over the current period included continued operation of the first mercury oxidation catalyst pilot unit at the CCS site with all four catalysts installed and sonic horns in operation for on-line catalyst cleaning, and continued operation with all four catalysts installed in the second pilot unit at CPS' Spruce plant (but no sonic horns).

The pilot unit at CCS is installed at the outlet of an induced draft fan and downstream of the cold-side electrostatic precipitator on Unit 1. An SCR catalyst and a palladium-based catalyst (Pd #1) have been in operation since October 3, 2002. A subbituminous ash-based catalyst, SBA #5, was placed in service the first week in December 2003. The fourth, Carbon #6 (C #6) catalyst was installed and placed in service on June 5, 2003. During the current quarter, one set of catalyst activity measurements was made by mercury SCEM at CCS and Ontario Hydro relative accuracy tests were conducted, and the pilot unit was monitored from off site to observe catalyst pressure drop values.

After 13 months of operation with sonic horns in service for on-line catalyst cleaning, they appear to be effective in limiting fly ash buildup in the horizontal gas flow catalysts for three of the four catalysts. However, this observation is confounded by apparent measurement problems with the catalyst pressure drop transducers. During the quarter, the signals from the four catalyst transducers were very noisy, an effect thought to be due to moisture condensation in the tubing to the transducers during previous cold weather operation. For the C #6, Pd #1, and SCR catalysts, the average pressure drop values appear to remain below 1 in. H_2O. For the fourth catalyst, SBA #5, after several fluctuations the pressure drop was up to about 4 in. H_2O at the end of the quarter. At the end of the quarter this catalyst was removed, and was observed to be mostly plugged with fly ash buildup. This suggests that the sonic energy level was not sufficient to prevent fly ash buildup across this fly-ash-based catalyst, perhaps due to electrostatic attraction effects.

A catalyst activity measurement trip conducted in June showed 79% Hg^0 oxidation for the C #6 catalyst, about 67% oxidation for the Pd #1 catalyst, but significantly lower activity (<30% oxidation) for the SCR and SBA #5 catalysts, all as measured with a mercury SCEM.

At CPS' Spruce Plant, catalyst activity results were measured during the month of May. These measurements showed that the fabric filter outlet flue gas mercury content is still highly oxidized (~75% or greater), in spite of the fabric filter having recently been rebagged. The fabric filter was rebagged in January/February, replacing 11-year-old bags. It was hoped that new bags would reduce the observed mercury oxidation across the fabric filter. Based on the May results, the new bags did not markedly impact mercury oxidation across the fabric filter. The relatively low inlet elemental mercury concentrations to the pilot unit (about 2-3 $\mu g/Nm^3$) make it difficult to quantify catalyst oxidation activity. To improve the accuracy of the mercury oxidation measurements, for this trip, two mercury SCEMs were used so the catalyst inlet and outlet mercury concentrations could be measured simultaneously. Also a new mercury SCEM with a

more sensitive atomic absorption detector was used at the catalyst outlet location, to improve the ability to measure low elemental mercury concentrations. The catalyst activity results from this trip indicate greater than 90% elemental mercury oxidation across each of the four catalysts. This result is somewhat surprising, given that the previous trip results from February showed lower oxidation percentages for all four catalysts. This new result may be an effect of the improved measurement approach used for the May measurement trip. The next measurement trip will be in early August, and will be used to confirm these results.

An advantage of having a fabric filter rather than an ESP upstream of the catalyst pilot unit is that there has been no tendency for fly ash buildup in the catalyst chambers. No sonic horns have been installed on the pilot unit at Spruce, and the pressure drop across all four catalysts remains below 0.3 in. H_2O.

No subcontracts were issued during the current reporting period.

Problems Encountered

There were no significant new problems encountered during the reporting period, other than the technical issues described in Section 4 of this report and mentioned above.

Plans for Next Reporting Period

During the next reporting period (July 1 through September 30, 2004), pilot-scale wet scrubber tests will be conducted at Coal Creek with flue gas from downstream of the C #6 and Pd #1 catalysts, as part of another DOE-funded project (DE-FC26-04NT41992), to determine how effectively the catalytically oxidized mercury will be scrubbed. Also, in situ, thermal catalyst regeneration tests will be conducted on the SCR, C #6 and Pd #1 catalysts. After the regeneration tests are completed, the pilot unit will be removed from CCS and will be shipped to TXU's Monticello Station as part of the 41992 project.

Operation of a second oxidation catalyst pilot unit, at CPS' Spruce Plant, will continue with all four catalysts installed. Routine sampling trips will be conducted to evaluate catalyst activity. Ontario Hydro relative accuracy tests for the mercury SCEM will also be conducted during the quarter.

Prospects for Future Progress

During the next reporting period (October 1 through December 30, 2004), no testing is scheduled at the CCS site, as the pilot unit will have been shut down. At the second site, CPS' Spruce Plant, pilot unit operation should continue until the end of calendar year 2004, and catalyst activity will be evaluated for elemental mercury oxidation activity through routine (~bimonthly) evaluation trips. Intensive gas characterization efforts should occur at the end of the test period, approximately in December 2004.

EXPERIMENTAL

The work described in this technical progress report was conducted using two different experimental apparatuses. One is an elemental mercury catalyst oxidation pilot unit (8000 acfm of flue gas treated) located at GRE's CCS Station in North Dakota. A second, nearly identical pilot unit is located at CPS' Spruce Plant. Each pilot unit has four separate compartments that allow four different catalysts to treat flue gas from downstream of the host plant's particulate control device and upstream of its FGD system. Details of the pilot unit design, construction, catalyst preparation and pilot unit operation have been discussed in previous quarterly technical progress reports[1,2, 3, 4].

The activity of these catalysts is being determined by measuring the change in elemental mercury concentration across each catalyst, while ensuring that the total mercury concentrations do not change significantly across the catalyst. These measurements are primarily being conducted using a mercury semi-continuous emissions monitor (SCEM) developed with funding from EPRI. The analyzer has been described in a previous report[5]. Periodically, the analyzer results are being verified by conducting manual flue gas sampling efforts in parallel across each catalyst chamber by the Ontario Hydro method.

The second experimental apparatus is a bench-scale test unit that is used to evaluate the activity of candidate catalyst cores under simulated flue gas conditions. However, no bench-scale tests were conducted during the current quarter. The bench-scale catalyst oxidation test apparatus was previously described in quarterly technical progress reports[3, 4].

RESULTS AND DISCUSSION

This section provides details of technical results for the current reporting period, April 1, 2004 through June 30, 2004. The technical results presented include a discussion of the data from the first pilot unit at GRE's CCS and the second pilot unit at CPS' Spruce Plant.

Pilot Unit Operation at CCS

Background

As described in the previous quarterly reports, the first pilot unit started up at CCS with the SCR and Pd #1 catalysts the first week of October 2002. The other two catalysts (SBA #5 and C #6) were not yet available. Initial catalyst activity measurements, by mercury SCEM, showed over 90% oxidation of elemental mercury across the Pd#1 catalyst, while the SCR catalyst results showed lower oxidation, in the range of 60 to 70% oxidation across catalyst. Throughout this report, elemental mercury oxidation percentages across catalysts are reported based on the measured decrease in elemental mercury concentration across the catalyst, and do not just reflect the total flue gas mercury oxidation percentage at the catalyst outlet.

In December 2002, the third catalyst, SBA #5, was installed. Measurement results showed a marked decrease in activity for both the Pd #1 and SCR catalysts. Follow-up testing in January determined that the catalyst surfaces were becoming plugged due to buildup of fly ash in the horizontal-gas-flow catalyst cells, in spite of the catalysts being installed downstream of a high-efficiency ESP. This was confirmed by tracking pressure drop increases across the catalysts and by opening and physically inspecting the catalyst chambers to observe and clean out the fly ash buildup.

It appeared that mechanical catalyst cleaning would be needed on the pilot unit for the horizontal-gas-flow catalysts. Both air soot blowers and sonic horns were considered. It was decided that a sonic horn would be the easiest field retrofit and would offer a good probability of success. A small, 17-inch horn produced by Analytec Corporation of Pagosa Springs, Colorado appeared to be the best solution based on price, availability, and probability of success. During the last week of March 2003, the sonic horn was installed on the Pd #1 catalyst box to provide occasional pulses of acoustic energy to the catalyst to dislodge accumulated particulate matter. The horn was installed on the top wall of the catalyst housing inlet transition, approximately 1.5 feet upstream of the first catalyst module. The horn sounds for 10 seconds every half hour. When the sonic horn was installed, the catalyst housing was opened and the Pd #1 catalyst modules were cleaned.

The pilot unit was placed back in service March 27, and the horn proved to be effective at controlling pressure drop across the Pd #1 catalyst. A catalyst activity measurement trip was conducted one month later. While the Pd #1 results were confounded by apparent mercury adsorption across the catalyst (i.e., a portion of the drop in elemental mercury concentration across the Pd #1 could be due to adsorption rather than oxidation) they otherwise showed high (~90%) elemental mercury oxidation across the catalyst. Based on the relatively high activity

and low pressure drop values for Pd #1, sonic horns were installed on the other three boxes the first week of June 2003.

Catalyst Pressure Drop Results

With the horns in service, the pressure drops across three of the four catalysts appear to have remained low. However, as had begun during the previous quarter, the signals for pressure drop across all four catalyst boxes continued to be very noisy.

Pressure drop values since June 5, 2003 are plotted for the Pd #1 and SBA #5 catalysts in Figure 1. If all four catalyst pressure drop values were plotted, the plot would become indecipherable due to the noisy signals. However, the data plotted in Figure 1 illustrate the difference in performance between the one catalyst that has not been kept clean by the sonic horn (SBA #5) and the other three that have (as illustrated by the Pd #1 data).

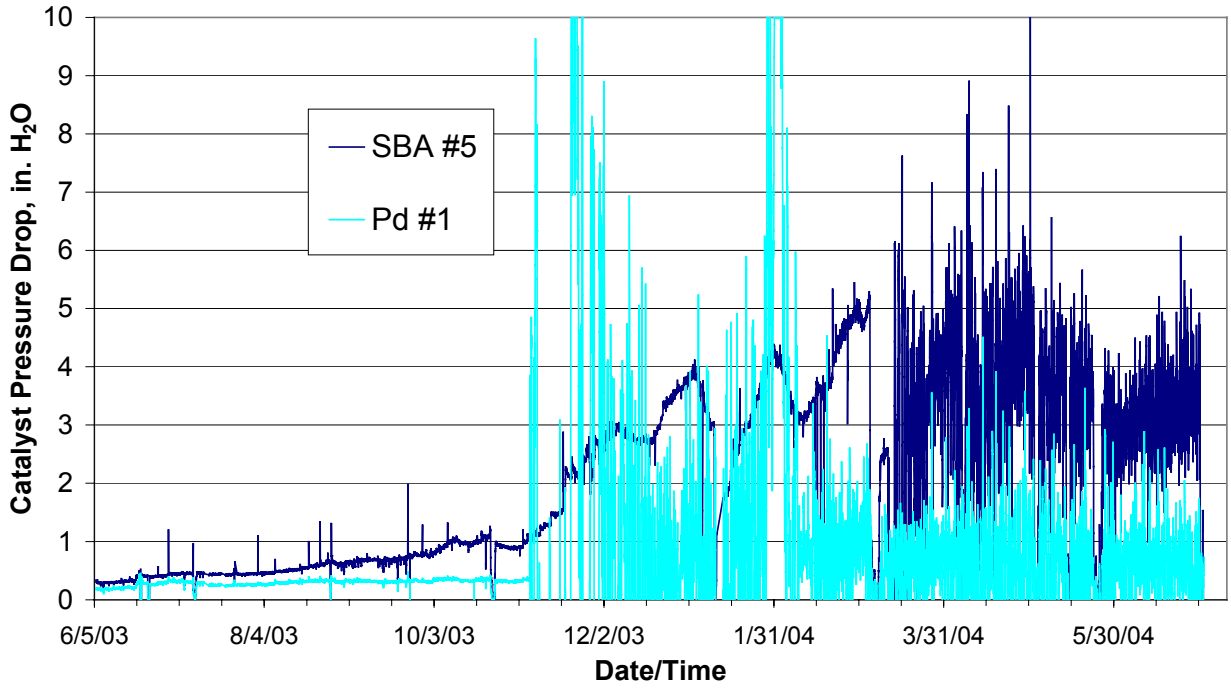

Figure 1. Pressure Drop Data for the Catalysts in Service at CCS through December

The SBA #5 pressure drop has increased over time, and averaged between 3 and 5 in. H_2O during the quarter. This is more than 10 times the initial pressure drop on June 5, 2003. It appears that there is a particle-to-particle attraction between the fly ash in the flue gas treated and the fly ash imbedded in the catalysts. This catalyst type is of lesser interest for future commercial applications, so regardless of the cause, the pressure drop increase across this catalyst chamber is not of great concern.

As seen in Figure 1, the average pressure drop across the Pd #1 remains below 1 in. H_2O, indicating the effectiveness of the sonic horn in preventing fly ash buildup across this catalyst. The other two catalysts appear to have similar pressure drop values to those of Pd #1.

Catalyst Activity Results

One catalyst activity measurement trip was made to CCS during the quarter, during the last week in June. The results of the catalyst activity measurements (by SCEM) are shown in Table 1.

Table 1. Oxidation Catalyst Activity Results for CCS Pilot (measured by Hg SCEM)

Location	Total Hg (μg/Nm^3, corrected to 5% O_2)	Elemental Hg (μg/Nm^3, corrected to 5% O_2)	Apparent Total Hg Adsorption Across Catalyst, %	Apparent Hg^0 Oxidation Across Catalyst, %	Overall Hg Oxidation Percentage
Results from 6/26/04:					
Pilot Inlet	13.2	9.46	-	-	28
Pd #1 Outlet	12.8	3.12	3	67	76
Pd #1 Outlet (low flow, 1500 acfm)	11.7	3.01	11	68	74
Results from 6/27/04:					
Pilot Inlet	15.4	11.0	-	-	28
SCR Outlet	15.3	8.14	1	26	47
SCR Outlet (low flow, 1200 acfm)	14.9	9.54	4	13	36
Results from 6/28/04:					
Pilot Inlet	15.0	9.89	-	-	34
C #6 Outlet	14.6	2.09	3	79	86
C #6 Outlet (low flow, 1500 acfm)	14.0	1.67	4	83	88
Results from 6/28/04 (p.m.):					
Pilot Inlet	15.5	10.6	-	-	32
SBA #5 Outlet	15.6	9.28	0	12	40

The inlet flue gas mercury concentrations varied over the typical range for CCS, from about 13 μg/Nm^3 to nearly 16 μg/Nm^3 of total mercury. The observed pilot unit inlet mercury oxidation percentage ranged from 28 to 34%. As has been seen in results presented in previous technical progress reports, three of the four catalysts appeared to be adsorbing a small amount of mercury from the inlet flue gas, ranging from 1% to 11% apparent adsorption. However, this small amount of mercury adsorption could be within measurement error given the fluctuating total inlet mercury concentrations seen over the course of a day.

The activity of the C #6 and Pd #1 catalysts remained relatively high, with 79% Hg^0 oxidation across the C #6 catalyst and 67% Hg^0 oxidation across the Pd #1 when measured at their normal

flue gas flow rates of 2000 acfm each. The measured activity for the C #6 was several percentage points lower than was measured last, in February. Both catalysts showed a small increase in Hg^0 oxidation percentage when the flue gas flow rate was reduced to 1500 acfm.

The activities of the SBA #5 and SCR catalysts continue to be lower than the C #6 and Pd #1 catalysts, in the range of about 12% to 26% Hg^0 oxidation. The activity of the SBA #5 catalyst had dropped measurably since February, but the SCR catalyst was virtually unchanged.

The "clean catalyst" activity results for all four catalysts are plotted versus time in Figures 2 and 3. Some data points from late 2002 and early 2003, where the catalysts were obviously plugged with fly ash, have been edited from the plots. Activity results for the Pd #1 and C #6 catalysts are plotted in Figure 2 and results for SBA #5 and SCR catalysts in Figure 3. Within the range of measurement variability, the data plotted in Figure 2 show a linear downward trend in the catalyst activity versus time in service for the two more active catalysts. The June measurements will be considered the "end of test" activity for the catalysts being tested at CCS, so the linear least squares fit of these data shown in the figure will be used to make catalyst life projections.

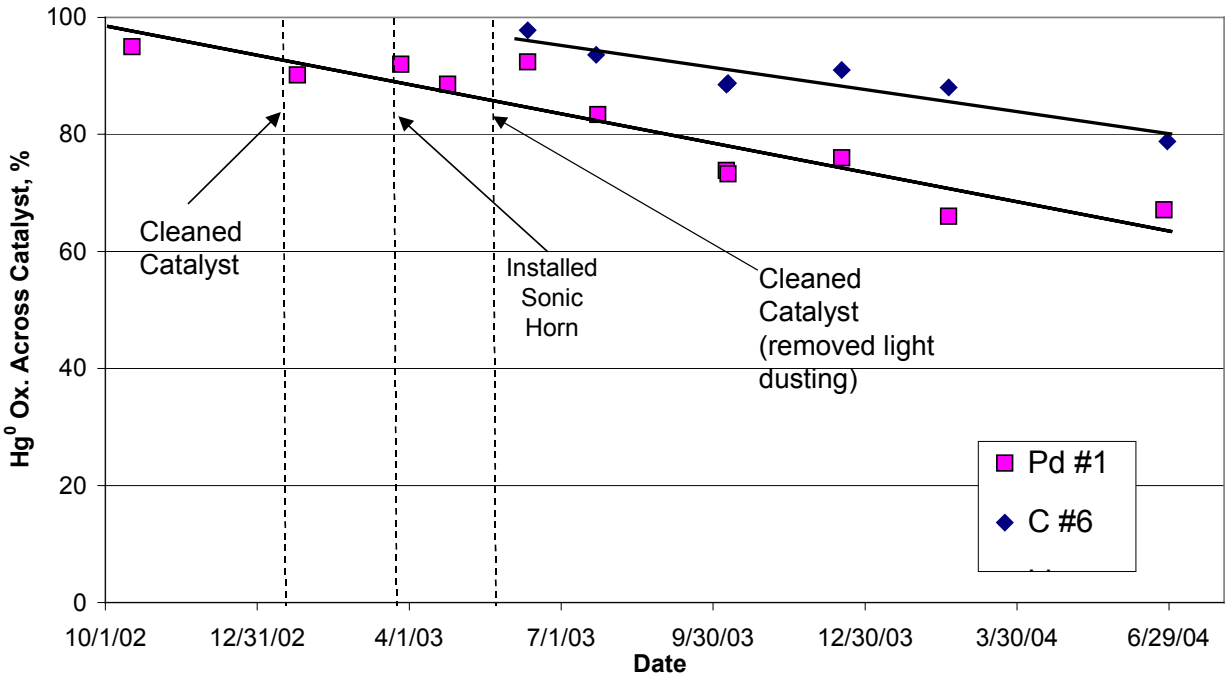

Figure 2. Activity for Hg^0 Oxidation versus Time for Pd #1 and C #6 Catalysts at CCS.

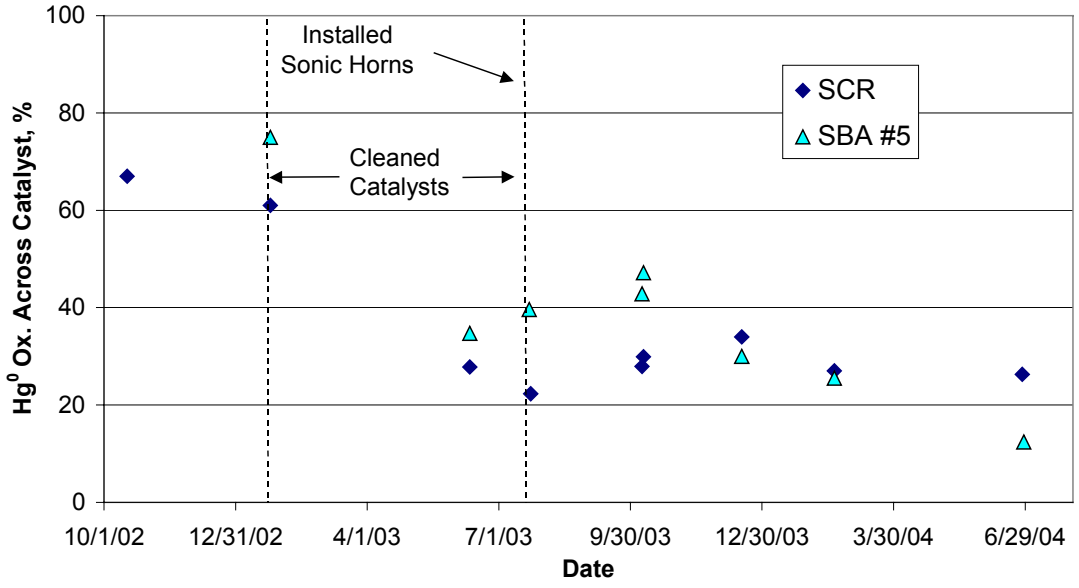

Figure 3. Activity for Hg^0 Oxidation versus Time for SCR and SBA #5 Catalysts at CCS.

The data plotted in Figure 3 show relatively "flat" activity performance for the SCR catalyst over time since the sonic horns were installed last June, albeit at relatively low oxidation percentages. The apparent activity of the SBA #5 catalyst has continually decreased with time since September 2003, most likely due to fly ash build up across this catalyst.

In July, attempts will be made to thermally regenerate the SCR, Pd #1 and C #6 catalysts. After a period of heating each catalyst with 600°F air, catalyst activity will be tested on flue gas to determine if the elemental mercury oxidation activity increased.

Also, in June, Ontario Hydro relative accuracy tests were conducted across the SCR, Pd #1 and C #6 catalysts during simultaneous measurements with the mercury SCEM. These Ontario Hydro results are not yet available, and will be reported in the next quarterly Technical Progress Report.

Pilot Unit Operation at Spruce Plant

Background

The pilot unit was started up at Spruce Plant in late August 2003 and operated with the Pd #1 and Au catalysts installed for most of the month of September. The host unit came off line for a fall outage the evening of September 26, and the outage continued until October 27. The two remaining catalysts (SCR and C #6) were installed in the pilot unit and the pilot unit was restarted on November 13, about two weeks after the host unit came back on line. The unit has operated continuously with all four catalysts on line since then.

Pilot unit inlet and catalyst outlet mercury concentration data were collected at Spruce the week of December 8. SCEM relative accuracy tests by the Ontario Hydro Method were conducted at the same time. The week of January 5, two SCEMs were taken to the site and used to measure flue gas total mercury and elemental mercury concentrations at the fabric filter inlet and outlet, and at the wet FGD outlet locations on the host unit. These measurements were made to develop a baseline characterization of host unit flue gas mercury conditions prior to rebagging the fabric filter with new bags. The rebagging began on January 12. Routine catalyst activity measurements by Hg SCEM were made on February 13, after 11 of the 14 compartments in the west fabric filter (directly upstream of the catalyst pilot unit) had been rebagged. The rebagging was completed at the end of February. These results have all been reported previously.

During the current quarter, catalyst activity measurements were made across all four catalysts using two mercury SCEMs. It was thought that using two instruments to measure inlet and outlet mercury concentrations simultaneously would provide a better measurement of catalyst activity given the low and variable inlet elemental mercury concentrations to the pilot unit.

Catalyst Pressure Drop Results

The pressure drop across the four catalyst chambers at Spruce remained nearly constant between 0.2 and 0.3 in H_2O during the current quarter. It does not appear that sonic horns will be required to prevent fly ash buildup, most likely because a high-efficiency reverse-gas fabric filter is used for particulate control at this site. The use of a fabric filter results in a low dust loading in the pilot unit inlet flue gas, and a dust loading that has less residual electrostatic charge than would flue gas downstream of an ESP.

Catalyst Activity Results

One set of catalyst measurement trip results are presented in this report, from May 2004. These results are shown in Table 2.

Table 2. May Oxidation Catalyst Activity Results for Spruce Pilot (measured by Hg SCEM)

Location	Total Hg (μg/Nm^3, corrected to 5% O_2)	Elemental Hg (μg/Nm^3, corrected to 5% O_2)	Apparent Total Hg Adsorption Across Catalyst, %	Apparent Hg^0 Oxidation Across Catalyst, %	Overall Hg Oxidation Percentage
Pd #1 Inlet	10.7	1.89	-	-	82
Pd #1 Outlet	9.91	0.12	7	94	99
C #6 Inlet	10.3	2.01	-	-	80
C #6 Outlet	10.3	0.19	0	91	98
Au Inlet	11.1	2.75	-	-	75
Au Outlet	10.5	0.21	5	92	98
SCR Catalyst Inlet	10.8	2.30	-	-	79
SCR Catalyst Outlet	11.2	0.13	0	94	99

As has been previously reported, the measurements at the pilot unit inlet showed high mercury oxidation percentages, with SCEM measurements showing 75% to 82% oxidized rather than the expected 20 to 30% oxidized mercury typical of PRB flue gases. This effect appears to be an influence of the fabric filter used for particulate control at Spruce. The fabric filter operates at a low air-to-cloth ratio (less than 1.5 acfm/ft^2) and at flue gas temperatures below 300^oF. The fabric filter was rebagged during the previous quarter, with little apparent effect on mercury oxidation across the baghouse. Therefore, it appears that bag aging effects had not greatly influenced the previous mercury oxidation percentages measured across this baghouse. The baghouse outlet elemental mercury concentrations measured ranged from 1.9 to 2.8 μg/Nm^3, which are not at high as would be desired from the standpoint of being able to measure oxidation catalyst performance.

Measurement of catalyst activity at Spruce is difficult for two reasons. One is that because of mercury oxidation and capture across the fabric filter, the elemental mercury concentrations at the oxidation catalyst pilot unit are relatively low, typically less than 3 μg/Nm^3 as mentioned above. This means that for well performing catalysts, the catalyst outlet elemental mercury concentrations are less than 1 μg/Nm^3, a low concentration that is difficult to measure accurately with the mercury SCEM (or by any other method). The second difficulty is that the pilot inlet total and elemental mercury concentrations can change significantly throughout the day, perhaps being impacted by factors such as fabric filter pressure drop and compartment cleaning cycles. A single Hg SCEM is normally used to quantify catalyst performance and must cycle between the pilot inlet flue gas sample and the catalyst chamber outlet samples, so inlet concentration variations can markedly impact observed mercury adsorption and elemental mercury oxidation percentages.

Because of these previous difficulties in measuring catalyst performance, two mercury SCEMs were used during this trip, one dedicated to measuring inlet mercury concentrations while the other cycled through the four catalyst chamber outlets. URS' newest, highest resolution analyzer was used for measuring the catalyst outlets, and increased measurement cycle times were employed so that the amount of mercury captured on the analyzer gold trap was above the low instrument calibration standard.

With the approach taken for measuring catalyst performance this trip, it appears that all of the catalysts are performing well, with each measuring greater than 90% oxidation and none adsorbing mercury in significant quantities. The data quality from this trip looks good - the analyzer calibrations looked good, and the cold vapor atomic absorption analyzers used in the SCEMs were producing sharp peaks when the mercury came off the gold.

All of the catalyst activity results from Spruce since September 2003 are plotted in Figure 4. The catalyst activity results show quite a bit of variability over time, and during some measurement periods the mercury oxidation percentages are much lower than expected. The most recent data, from the May measurement trip which are believed to be the most reliable, show that all four catalysts are achieving greater than 90% oxidation of the inlet elemental mercury. The next measurement trip is scheduled for early August, and will provide an opportunity to see whether the high activity results measured in May will be repeated.

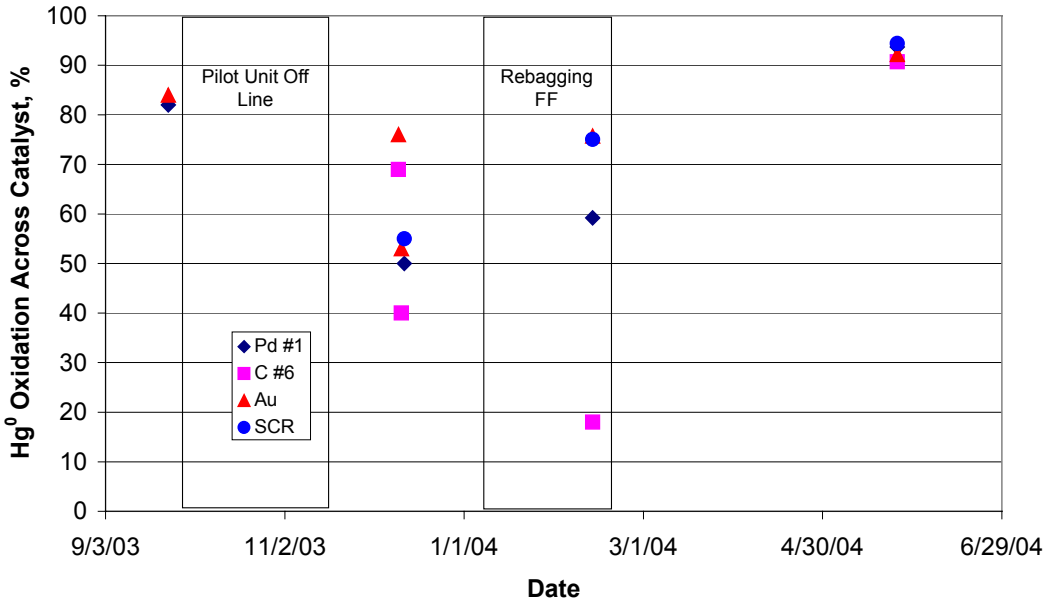

Figure 4. Catalyst Activity Versus Time in Service at Spruce Plant

Laboratory Evaluation of Candidate Catalysts

No laboratory evaluations were conducted during the current quarter.

CONCLUSION

Because of the observed ash accumulation on the catalysts at CCS, provisions had to be made to keep catalyst surfaces cleaner. Sonic horns are commonly used to clean catalysts on line in utility SCR applications for NO_X control, and appear to be similarly effective in this application (lower dust loading but horizontal gas flow). In 13 months of operation, the horns have apparently been effective at limiting fly ash buildup in three of the four catalysts. For the fourth catalyst, SBA #5, it appears that the sonic energy from the horn has not been sufficient to prevent fly ash accumulation (and loss of activity) across this catalyst, perhaps because of electrostatic attraction between the fly ash particles in the flue gas and catalyst.

Catalyst activity measurements in June indicate that the horns have also been effective in maintaining catalyst activity for two more active catalyst materials. After 21 months of operation, the Pd #1 catalyst has seen some long-term loss in activity for elemental mercury oxidation, from slightly greater than 90% to between 65 and 70%. After nearly 13 months of operation, the C #6 catalyst has dropped from greater than 95% to between 75 and 80%. The SCR catalyst has seen a more significant loss, dropping from 67% to less than 30% oxidation over a 21-month period (as measured by SCEM). The SBA #5 catalyst has dropped from 75% oxidation to about 12% oxidation over a 19-month period (also based on SCEM results), although fly ash buildup has contributed to this loss. The catalyst testing at CCS was ended after the June activity measurements.

For the Pd #1, SCR and SBA #5 catalysts, the activity results may be confounded by the fly ash buildup experienced prior to the sonic horn installations. The fly ash buildup could have had beneficial or negative effects on catalyst activity. If the catalysts are deactivated by species in the flue gas, the honeycomb cells that were blocked by fly ash buildup may have been "protected" from deactivation by flue gas species. Conversely, the fly ash buildup could have directly affected catalyst activity in an adverse manner through physical blockage or chemical reactions at active sites. The C #6 has operated with a sonic horn in service to prevent fly ash buildup for its entire 13 months of operation, so the results for this catalyst have not been confounded in this manner.

At the Spruce site, the fabric filter upstream of the pilot unit has had two implications on the pilot testing. One is that is does not appear that sonic horns will be required to keep fly ash from accumulating within the catalyst cells. The other implication is that the fabric filter oxidizes a high percentage of the elemental mercury in the air heater outlet flue gas, so the inlet gas to the pilot unit contains relatively low elemental mercury concentrations (typically 1 to 3 $\mu g/Nm^3$). This makes evaluation of catalyst performance difficult, as it is difficult to quantify flue gas elemental mercury concentrations below 1 $\mu g/Nm^3$.

Based on results from May, all four catalysts (Au, C #6, Pd #1 and SCR catalysts) are achieving greater than 90% elemental mercury oxidation in this PRB flue gas. During the upcoming quarter, site measurements will be conducted to determine whether these high catalyst activity results will be repeated.

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